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(56) Documents Cited

GB 2356959 A GB 2346998 A
WO 95/05649 A1 FR 002742706 A1
US 5745031 A

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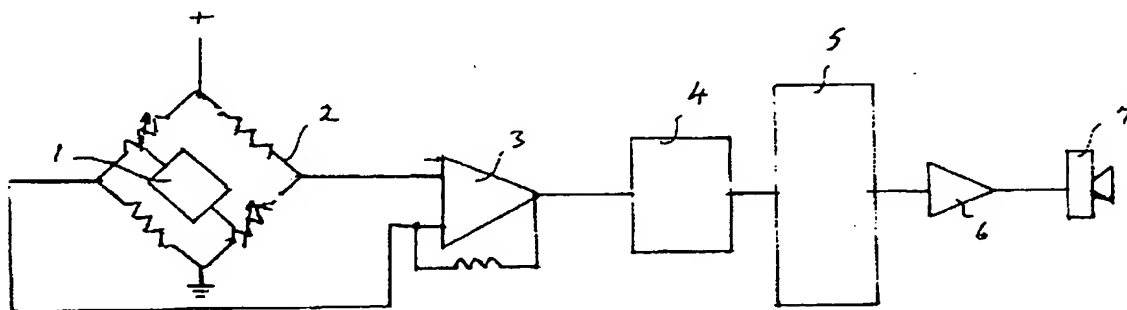
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(54) Abstract Title

Detecting fatigue in machine operator or vehicle driver

(57) A pattern of operator or driver control actions is measured at the start of a period of operation of the machine or vehicle, stored, and then compared with later determined or calculated patterns or profiles of control actions. When the differences exceed a predetermined amount, a warning signal is initiated and, if appropriate, the machine or vehicle is brought to rest.

In a road vehicle, a pressure sensor 1 forms part of the steering wheel and a processor 5 analyses and records the pattern of variations in effort applied to the wheel by the driver over a period of time. An initially stored pattern is then compared with successive patterns during the period of driving. Other factors, such as steering wheel deflection, accelerator or brake pedal use, road speed, suspension movements, roll and vehicle position, may be taken into account by the processor.

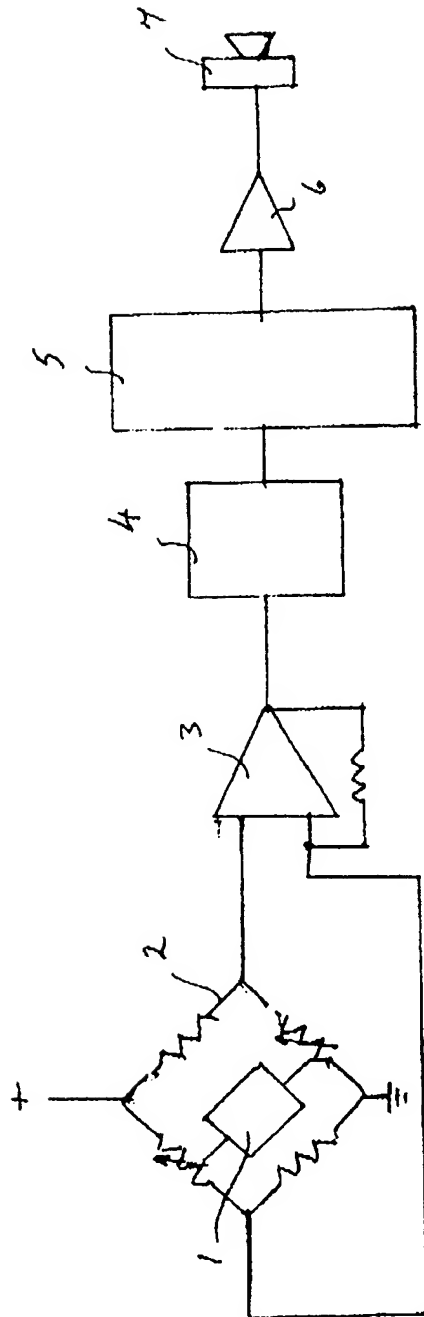


The claims were filed later than the filing date but within the period prescribed by Rule 25(1) of the Patents Rules 1995.

This print incorporates corrections made under Section 117(1) of the Patents Act 1977.

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DRIVER FATIGUE DETECTOR

The present invention relates to systems for detecting the onset of machine operator fatigue, and more specifically, to systems for detecting the onset of fatigue in the drivers of motor vehicles.

It is becoming recognised that an appreciable number of motor vehicle accidents, which involve an apparently inexplicable loss of control of a mechanically sound vehicle, are in fact due to the driver concerned falling asleep. Indeed, one now sees signs on motorways and trunk roads advising drivers to "take a break: tiredness kills".

A well-known system for preventing a train or crane running out of control in the event of a collapse of its driver is the so-called "Dead man's" handle, which is a spring-loaded lever that the driver has to keep pressed down to maintain a control switch closed. Variations on this theme have been applied to motor vehicles, for example Specification WO 9622897 discloses a system in which a car steering wheel includes an annular switch which is biased to an open state with the switch operating ring urged away from the steering wheel rim. A driver of the vehicle has to apply pressure to keep the switch closed. Should he fall asleep or release his grip on the steering wheel, the switch is opened which activates a visual and audible warning system. Specification WO 9806077 discloses a similar system.

Other systems monitor the frequency and/or nature of steering movements: examples of such systems are disclosed in specifications EP 0117497 and EP 0119486.

Specification EP 0117497 discloses a system which infers a condition of driver drowsiness when the imbalance between the number of steering impulses in one direction and those in the other direction within a given time interval exceeds a predetermined value.

Specification EP 0119486 discloses a system, which infers a condition of driver drowsiness by measuring the duration of periods when no driving impulses occur and the magnitude and speed of steering impulses when they do occur.

- 5 Driver fatigue detectors of the first type have disadvantages that the need to grip a steering wheel relatively tightly can affect the delicacy of control of the vehicle, which is undesirable in adverse weather conditions. Also the need to maintain a continual grip on the steering wheel over an extended period can cause muscular discomfort, particularly to drivers who suffer
10 from arthritis or similar muscular complaints.

Systems of the second type do not suffer from this disadvantage, but may be confused by irregular road surfaces.

- It is an object of the present invention to provide an improved system for
15 detecting the onset of fatigue in the operator of a machine.

- According to the present invention there is provided a method of detecting fatigue in the operator of a machine comprising the operations of determining a reference pattern of control actions made by an operator of a
20 machine, storing the said pattern of control actions in a central control unit, continuously monitoring the said control actions, analysing and comparing the subsequently determined patterns of control actions with the stored patterns of control actions and operating a warning device when the subsequently determined patterns of control actions differ to the reference
25 or calculated pattern of control actions by a predetermined amount or compare to a calculated profile of fatigue for the operator of the machine

Also according to the present invention there is provided an apparatus for detecting the onset of fatigue in the operator of a machine and giving warning thereof comprising at least one transducer adapted to produce

signals indicative of control actions made by an operator of a machine, a central processing unit to which the said signals are applied and an alarm device adapted to respond to operator fatigue signals generated by the central processing unit, wherein the control processing unit is adapted to
5 determine and store a reference pattern of control actions made by the operator of the machine, determine at intervals a current pattern of control actions made by the operator of the machine, analyse and compare the reference and current patterns of control actions made by the operator of the machine and generate the operator fatigue warning signals when the
10 reference and current patterns of control actions differ by a predetermined amount or compare to a calculated profile of fatigue for the operator of the machine.

By determining and storing the reference pattern of control actions, the apparatus is able to accommodate the personal equation of any given
15 operator of the machine and any operating peculiarities of the machine.

The term control actions includes variations in the grip and forces applied to the control means by the operator of the machine, as well as movements of the control means from a rest, or neutral position.

20 In a particular embodiment of the invention, the machine is a motor vehicle and the operating control of the machine are the steering wheel, accelerator and brake pedals of the vehicle any of which are adapted to include at least one pressure transducer, strain gauge and/or position transducer.

25 The invention will now be described, by way of example, and with reference to the accompanying drawing, which is a block circuit diagram of a system embodying the invention for detecting fatigue in a driver of a motor vehicle. Referring to the drawing, a system for detecting fatigue in a driver of a motor vehicle consists of pressure sensors 1 which form part of a steering

wheel, accelerator and brake pedals of a vehicle, none of which are shown in the drawing, these are arranged to alter the balance of individual bridge circuits 2 by an amount which is a function of the effort applied to the steering wheel or pedals by a driver of the vehicle. The out-of-balance voltage developed across the bridge circuits 2 are applied to differential amplifiers 3. The outputs from the differential amplifiers 3 are applied to analogue-to-digital converters 4 and thence to a central processor 5. The central processor 5 is adapted to analyse and record the patterns of variations in effort applied to the driving wheel and pedals of the vehicle by the operator of the vehicle over a period of time. When the operator first begins to drive the vehicle and is alert the central processor 5 stores the correlated values of these variations to establish a norm for the driver concerned. Each person has a different posture and pattern of force applied, variations of grip, and steering movements and by the above process the central processing unit 5 effectively calibrates itself in relation to each driver of the vehicle. As time passes on a journey, the central processor 5, continuously monitors the said control actions, analysing and comparing the subsequently determined patterns of control actions with the stored patterns of control actions and when the subsequently determined patterns of control actions differ to the reference or calculated pattern of control actions by a predetermined amount or compare to a calculated profile of fatigue for the operator of the vehicle then the central processor 5 produces a warning signal which is applied to an amplifier 6 and thence to an alarm which may be visual, aural or both.

One form of force sensor, which can be used with a motor vehicle, is a sealed tube incorporated in the rim of the steering wheel of the vehicle. Changes in the volume of the tube as a motorist grips and releases the steering wheel will cause corresponding changes in pressure in the tube which can be detected by means of piezo electric diaphragms, the change in electrical

characteristics of which can be used to alter the balance of the bridge circuit

2. Alternatively, a number of strain gauges, or sensors designed to provide a change in capacitance or resistance depending on the drivers grip can be incorporated in the structure of the steering wheel.

5 In the case of a motor vehicle, the type of control actions, including the force with which the driver of the vehicle grips the steering wheel of the vehicle, are dependent upon a number of parameters, for example, a tortuous, or rough road requires a stronger grip than along straight or smooth road, as does a deliberate manoeuvre made by the driver of the vehicle or driving at
10 high speed.

In order that the central processor 5 can allow for these factors there can be provided further sensors, not shown in the drawing, which provide signals related to the road speed of the vehicle, the angle of turn of the steering wheel from the straight ahead position, the frequency and/or amplitude of
15 movements of the vehicle suspension system, the body roll, and possibly, the position of the vehicle derived from GPS (global positioning system) data. By analysing these data the central processor 5 can establish a new reference pattern of control actions when there is a consistent change in one or more of the above parameters, indicating a non-driver fatigue related
20 change in the driver's control actions or decide that certain changes in the driver's control actions should be ignored or acted upon. For example, a low speed and high angle of turn of the steering wheel would indicate that a manoeuvre, such as turning, is being carried out and can be ignored.

25 A similar result can be achieved by carrying out the determination of the reference pattern of control actions and also the current pattern of control actions over a period of time to determine a correlated pattern of current control actions.

Although the system can be made to affect the motion of the vehicle in the event that there is no response to the visual/aural alarm, in the case of a road vehicle there are disadvantages in so doing as an abrupt change in the motion of the vehicle could well cause an accident.

- 5 If the invention is applied to a train, crane or other machine, which operates within defined limits then this caveat, may not apply and the operator fatigue detection system safely can be made to bring the machine concerned to rest. If fitted to an aircraft the system could engage an autopilot and/or radio warning that the pilot is in difficulty.

Claims

1. A method of detecting fatigue in the operator of a machine comprising the operations of determining a reference pattern of control actions made by an operator of a machine, storing the said pattern of control actions in a central control unit, continuously monitoring the said control actions and comparing the subsequently determined patterns of control actions with the stored pattern of control actions and operating a warning device when the subsequently determined patterns of control actions differ from the initially determined pattern of control actions by a predetermined amount.
2. A method according to Claim 1 wherein there is included the operation of re-determining the reference pattern of control actions at intervals and replacing the stored reference pattern of control actions with the later determined reference pattern of control actions.
3. A method according to Claim 1 or Claim 2 wherein there is included the operation of determining variations in the gripping force applied by the operator of the machine to a control device associated with the machine.
4. An apparatus for detecting the onset of fatigue in the operator of a machine and giving warning thereof comprising at least one transducer adapted to produce signals indicative of control actions made by an operator of a machine, a central processing unit to which the said signals are applied and an alarm device adapted to respond to operator fatigue signals generated by the central processing unit, wherein the control processing unit is adapted to determine and store a reference pattern of control actions made by the operator of the machine, determine at intervals a current pattern of control

actions made by the operator fatigue of the machine, compare the reference and current patterns of control actions made by the operator of the machine and generate the operator fatigue warning signals when the reference and current patterns of control actions differ by a predetermined amount.

5. Apparatus according to Claim 4 wherein the central processor is adapted to re-determine the reference pattern of control actions at intervals and replace the stored reference pattern of control actions with the later determined reference pattern of control actions.
6. Apparatus according to Claim 4 or Claim 5 wherein a transducer adapted to produce signals indicative of control actions made by the operator of the machine is incorporated into a control device associated with the machine.
7. Apparatus according to Claim 6 wherein the said transducer is adapted to produce signals indicative of the gripping force applied to the said machine control device.
8. An apparatus according to Claim 6 or Claim 7 wherein the transducer comprises a sealed chamber containing a fluid, means for detecting changes in the pressure in the fluid as a result of the said control actions and means for producing electrical signals related thereto thereby to provide an indication of the control actions made by the operator of the machine.
9. An apparatus according to Claim 8 wherein the means for providing electrical signals related to changes in the pressure in the fluid as a result of the control actions comprises a diaphragm made of piezo-electric material.

10. An apparatus according to Claim 6 or Claim 7 wherein the transducer comprises at least one electrical strain gauge incorporated into the control device of the machine.
11. An apparatus according to any of Claims 6 to 10 wherein there is provided a transducer adapted to produce electrical signals indicative of the deflection of the control means from a neutral position.
12. An apparatus according to any preceding Claim wherein the machine is a motor vehicle and the control device is the steering wheel of the motor vehicle.
13. Apparatus according to Claim 12 when dependent on Claim 8 wherein the fluid-filled chamber is incorporated in the rim of the steering wheel.
14. Apparatus according to Claim 13 wherein the means for providing the said electrical signals is a diaphragm made of a piezo-electric material.
15. Apparatus according to Claims 12, 13 or 14 wherein there is included, sensors adapted to produce electrical signals related to the deflection of the steering wheel from a neutral position, the road speed of the vehicle the frequency and/or amplitude of movements of the suspension of the vehicle, and the roll of the body of the vehicle and the central processor is adapted to analyse these signals to determine changes in the operating envelope of the vehicle.
16. An apparatus according to any of Claims 4 to 15 wherein there is included means for providing a warning when the differences between the reference and current patterns of control actions exceed the predetermined amount.

17. An apparatus according to any of Claims 4 to 11 wherein there is included means for putting the said machine into a safe condition when the differences between the reference and current patterns of control actions exceed the predetermined amount.
18. A method of detecting fatigue in the operator of a machine substantially as hereinbefore described and with reference to the accompanying drawing.
19. An apparatus for detecting fatigue in the operator of a machine substantially as hereinbefore described and with reference to the accompanying drawing.



INVESTOR IN PEOPLE

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Claims searched: 1-19

Examiner: David Brunt
Date of search: 24 September 2001

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.S): G4N (NHVSB, NHX)

Int Cl (Ed.7): B60K (28/02, 28/06), G08B (21/06)

Other: Online: EPODOC, JAPIO, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
X,E	GB 2356959 A (REVELL) see whole document	1,4,6,8, 12,17
X,E	GB 2346998 A (PEARCE) see whole document	1-19
X	WO 95/05649 A1 (VORAD) see p.10 1.14 - p.11 1.25	1,2,4-6, 12,16
X	FR 2742706 A1 (CITROEN/PEUGEOT) see WPI Abstract Accession No. 1997-353177 [33]	1,4,6,16
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